

From SMF/MMF to Upcoming MCF/HCF: Fiber Standardization Updates

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ITU-T/IEEE joint WS - Emerging standards in the AI/ML, July 11, 2026

Outline

- Fibers and Cables for Datacenter Network in the AI era
- Traditional Fibers and their limits – SMF and MMF
- Next-Gen Fiber Technologies – MCF and HCF
- Summary

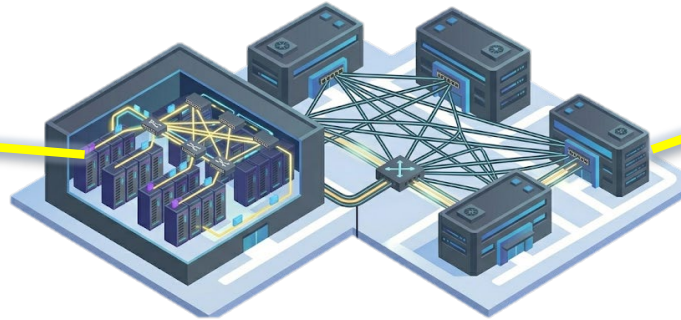
Current Landscape

Inter-rack
(<0.1 km)

Intra-DC/Campus
(0.5 - 10 km)

Inter-DC
(<100 km)

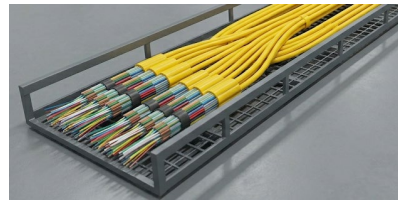
Core/Subsea
(1,000 km+)



Copper

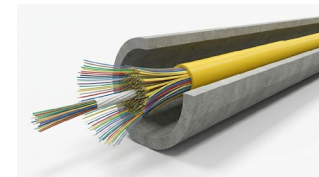
MMF

- ✓ Low latency
- ✓ Low energy



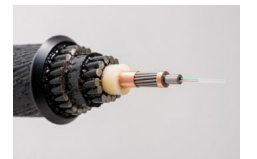
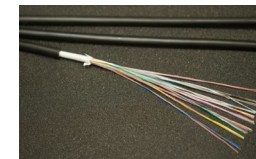
SMF (G.652/G.657)

- ✓ Massive parallelism
- ✓ IM/DD (in many case)

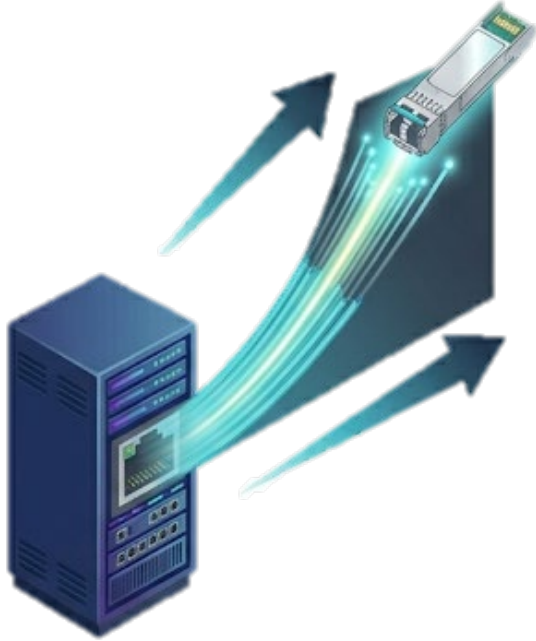


SMF (G.652/G.654)

- ✓ High capacity per cable
- ✓ Coherent & DWDM



Challenge for fiber and cable in the AI era



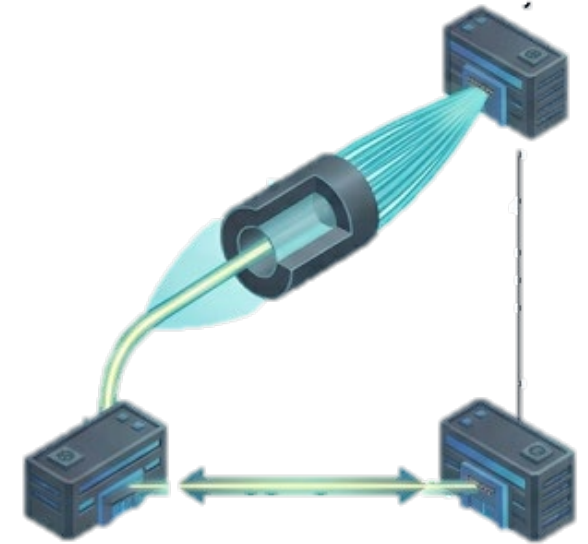
Scale-up

- ✓ Ultra-high bandwidth (Beyond 1T)
- ✓ Electrical to Photonic interconnects



Scale-out

- ✓ Extremely dense parallelism
- ✓ Physical limits of cabling and connectorization



Scale-across

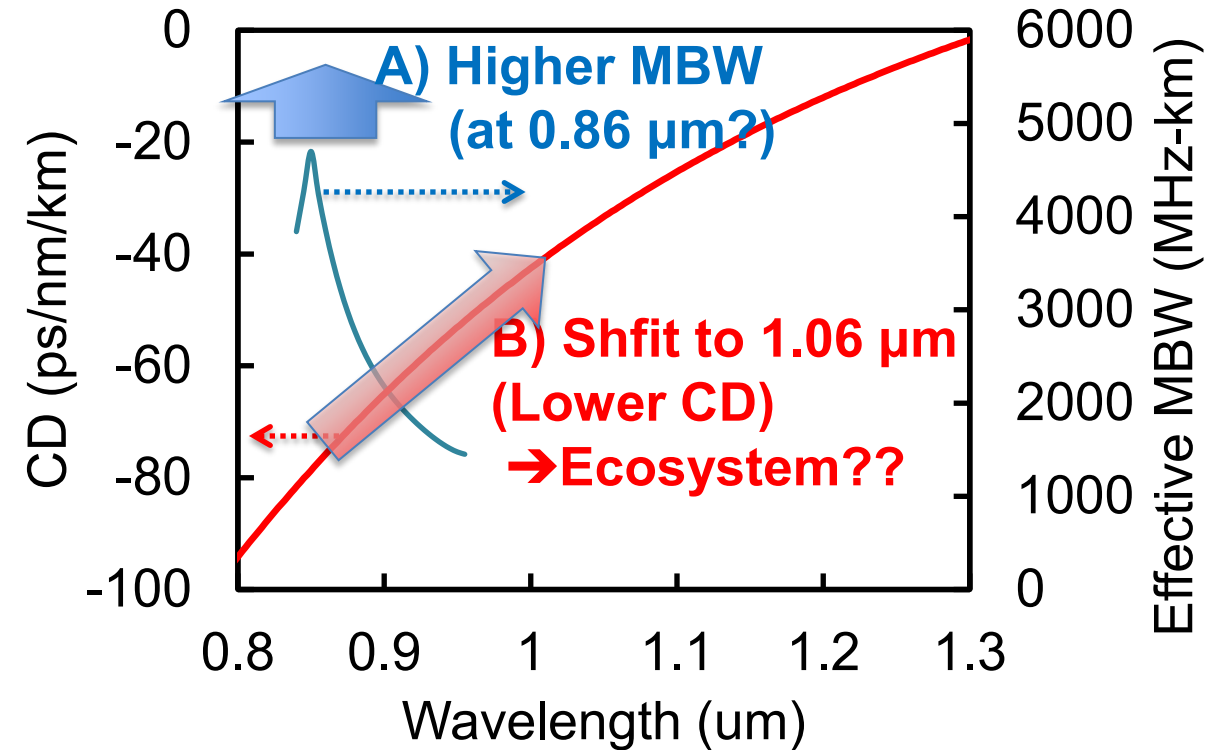
- ✓ Geographical distribution (power and environment)
- ✓ Low latency & massive capacity

MMF evolution & limits

	Lane speed	Max. reach	Limitation by
400G	50G-PAM4	100 m	MBW
800G	100G-PAM4	50 m	MBW&CD
1.6T	200G-PAM4	<30 m	CD

MBW: Modal bandwidth

CD: Chromatic dispersion

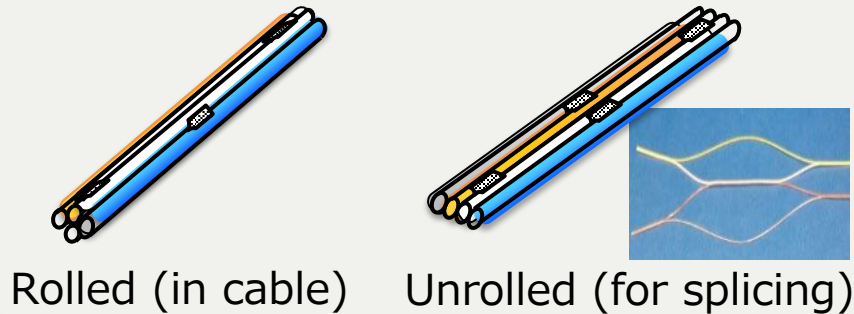


- Bandwidth and reach to be restricted by both MBW and CD
- IEC SC86A to start discussion for next-gen MMF specification

SMF for massive parallelism interconnect

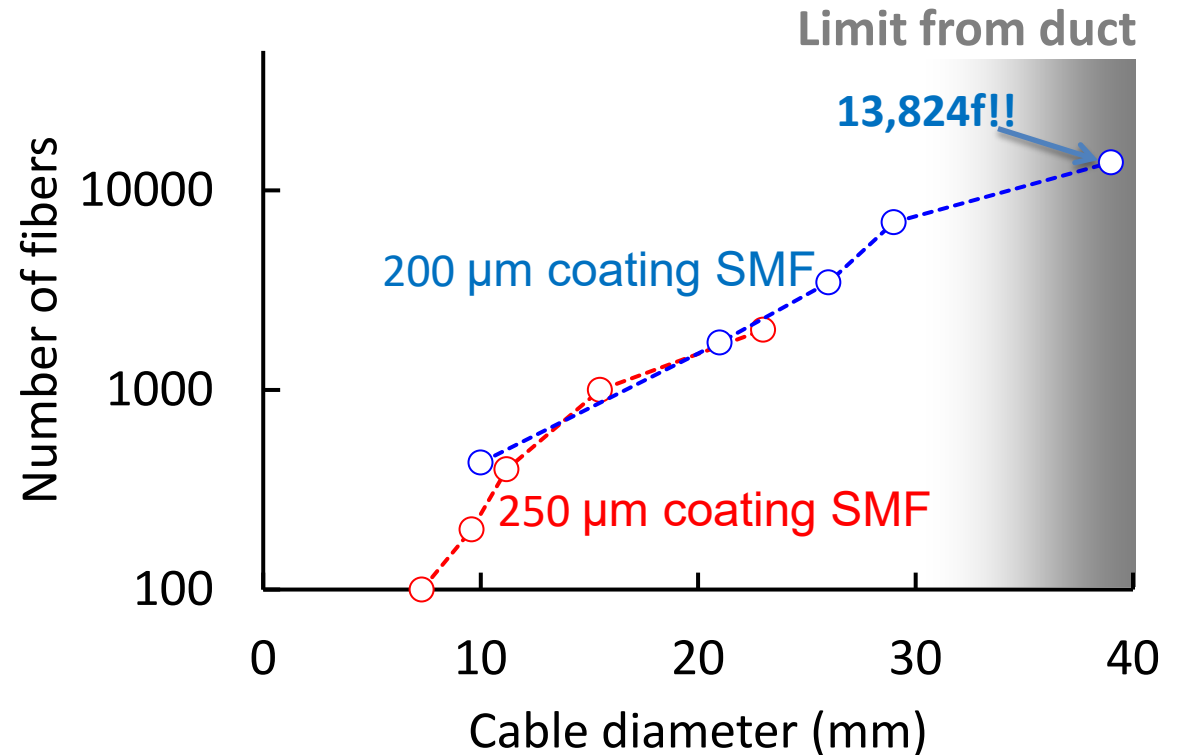
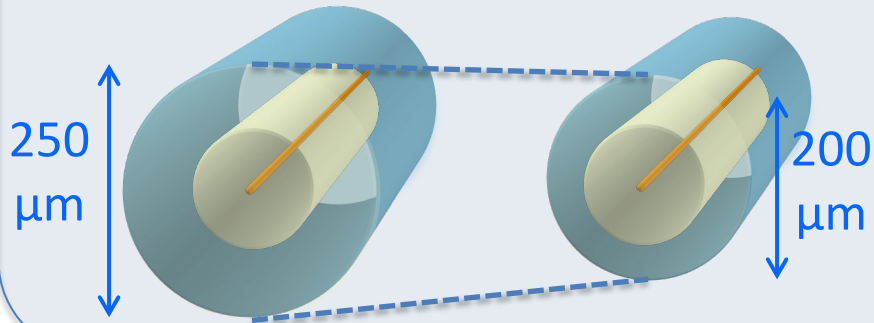
Rollable ribbon technology

(Specified at IEC60794-1-31 & ITU-T L.10x)



Reduced coating diameter

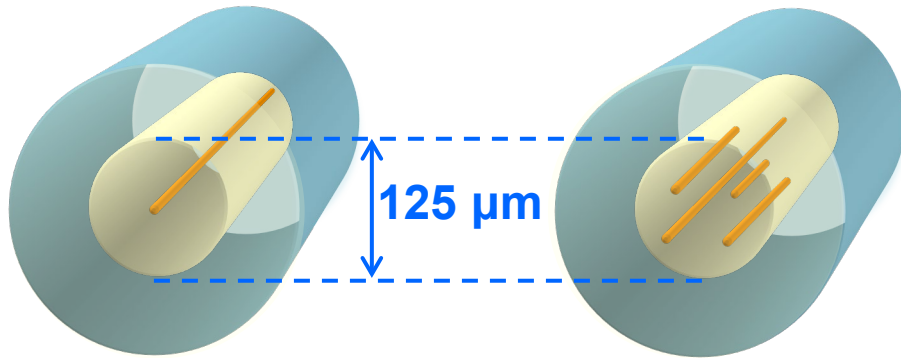
(Specified at IEC60793-2-50
and upcoming revised ITU-T 65x)



■ Higher density interconnection by
space division multiplexing (SDM) fibers?

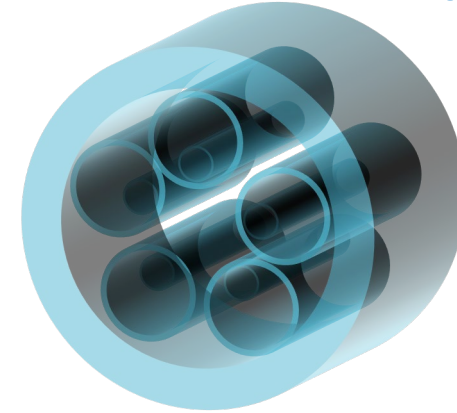
Next-Gen. Fiber Candidates

Multi-core fiber (MCF)



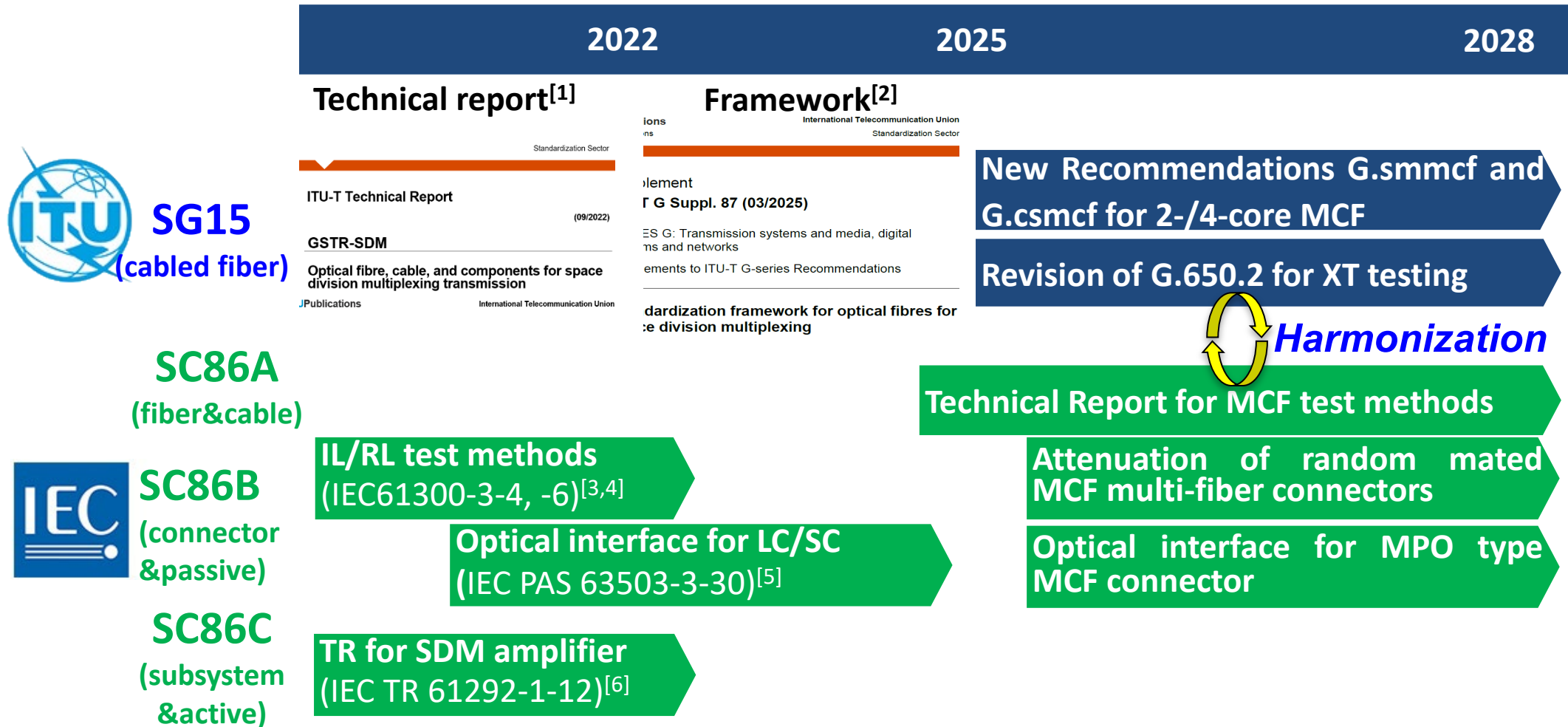
- ✓ Multiple (2 or 4) cores with **maintaining fiber diameter and optical backward compatibility with G.652/G.657 and G.654 fibers (G.smmcf and G.csmcf)**
- ✓ Consistency with existing cable, connector and optical components
- ✓ **“Scale-up” and “Scale-out” enabler** with massive capacity & parallelism

Hollow-core fiber (HCF)



- ✓ **Absolutely low latency (33 % reduction vs. silica glass), low attenuation and low nonlinearity**
- ✓ Fundamentally new physics & ecosystem
- ✓ **“Scale-across” enabler** to overcome geographical constraints

Standardization roadmap for MCF technology



[1] ITU-T GSTR-SDM, "Optical fibre, cable, and components for space division multiplexing transmission," (2022)

[2] ITU-T G. Suppl.87, "Standardization framework for optical fibres for space division multiplexing," (2025)

[3] IEC61300-3-4, Ed. 4.0 (2023)

[4] IEC61300-3-6, Ed. 3.0 (2008)

[5] IEC PAS 63503-3-30, Ed. 1.0 (2023)

[6] IEC/TR 61292-1-12, Ed. 1.0 (2022)

MCF Standardization Updates (Fiber)

□ Characterization

- Test methods and procedures for inter-core XT in ITU-T G.650.2
- Definition and test methods for MCF geometry in ITU-T G.650.1

□ Geometrical specification

- General description for core identification (marker and other approach)
- **Proposal of Core position for 4-core MCF:** 40 μm core pitch for G.smmcf and 40/43 μm core pitch for G.csmcf, still open for further discussion

□ Optical specification

- **Proposal of optical backward compatibility** with G.652.D fiber for 4-core G.smmcf, still open for discussion including compatibility with G.657.A fiber
- PMD for short reach to be still open for discussion

Further collaboration and harmonization with IEC and IEEE!

MCF Standarization Updates (Connector and FIFO)

□ MCF connector

- New standardization work on **connector interface for MCF-MPO connector** and test method for random mated multiple MCF connectors to be launched
- Connector interface for MCF-SC/LC connector and IL/RL test methods to be already standardized

□ MCF FIFO(fan-in/fan-out) devices

- Preliminary discussion on **test methods and experimental results for the inter-core XT of MCF-FIFO devices** for future standardization

Technical report on HCF

□ Starting to develop technical report GSTR-SDM “Hollow-core fibre technologies and systems”

- Joint activity among multiple Questions of Q2 (Access NW), Q5 (Optical fiber and cables) and Q6 (Terrestrial system IF)
- Agreement timing will be in 2028

□ Scope

- clarify key properties of hollow -core fibre (HCF)
- provide application scenarios, requirements and system considerations
- analyze interoperability
- discuss deployment and maintenance considerations
- discuss ecosystem development roadmap and potential path to standardization

IEEE802.3 will receive liaison statement for information

Summary

- **MMF:** New specs under discussion in IEC for higher-speed transceivers.
- **SMF:** Currently stable; further refinements may be discussed as needed.
- **MCF:** Active standardization (fiber & connectors) in harmonization with relevant SDOs.
- **HCF:** New Technical Report work initiated for clarifying HCF technology.

**IEEE
802**

